General

Guideline Title

ACR Appropriateness Criteria® acute chest pain — suspected pulmonary embolism.

Bibliographic Source(s)

Bettmann MA, Baginski SG, White RD, Woodard PK, Abbara S, Atalay MK, Dorbala S, Haramati LB, Hendel RC, Martin ET III, Ryan T, Steiner RM, Expert Panel on Cardiac Imaging. ACR Appropriateness CriteriaÂ® acute chest pain - suspected pulmonary embolism. [online publication]. Reston (VA): American College of Radiology (ACR); 2011. 7 p. [68 references]

Guideline Status

Note: This guideline has been updated. The National Guideline Clearinghouse (NGC) is working to update this summary.

Recommendations

Major Recommendations

Note: This guideline has been updated. The National Guideline Clearinghouse (NGC) is working to update this summary. The recommendations that follow are based on the previous version of the guideline.

ACR Appropriateness Criteria®

Clinical Condition: Acute Chest Pain–Suspected Pulmonary Embolism

Variant 1: Adult.

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	9	To exclude other causes of acute chest pain. Complementary to other examinations.	
CTA chest (noncoronary) with contrast	9	Current standard of care for detection of PE	
Ventilation-perfusion (V/Q) scan lung	4		

Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate

*Relative Radiation Level

Radiologic Procedure	Rating	Comments	RRL*
US lower extremity with Doppler	7	If chest x-ray is negative and index of suspicion is high.	O
CTA chest with contrast with CT venography lower extremities	6		
Pulmonary angiography with right heart catheterization	5	If suspicion is high and CTA is inconclusive, or if intervention is needed.	
MRA pulmonary arteries without and with contrast	4	If patient is unable to receive iodinated contrast, may be alternative to V/Q scan. See statement regarding contrast in text under "Anticipated Exceptions."	O
MRA pulmonary arteries without contrast	3		O
US echocardiography transesophageal	2	Limited experience. Has been used for central pulmonary emboli.	O
US echocardiography transthoracic resting	2	To assess for RV strain or failure in the presence of major pulmonary embolism.	O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 2: Pregnant patient.

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	9		
US lower extremity with Doppler	8		O
CTA chest (noncoronary) with contrast	7		
Tc-99m V/Q scan lung	7	Ventilation done only if necessary.	
Pulmonary angiography with right heart catheterization	4	Rarely indicated. For clarification or catheter-directed intervention.	
CTA chest with contrast with CT venography lower extremities	3		
MRA pulmonary arteries without and with contrast	3	May be used as a problem solver or if intervention is planned. Concern for fetal exposure to contrast.	O
MRA pulmonary arteries without contrast	3		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation

Radiologic Procedure	Rating	Comments	RRL*
US echocardiography transesophageal	2		O
US echocardiography transthoracic resting	2		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Summary of Literature Review

Introduction/Background

Over 290,000 cases of fatal pulmonary thromboembolism (PE) and 230,000 cases of nonfatal PE are estimated to occur in the United States each year. Additional cases may not be diagnosed because the symptoms of chest pain, shortness of breath, tachycardia, etc, are nonspecific and may mimic other pulmonary or cardiac conditions. Unsuspected PE continues to be a frequent autopsy finding.

It has been further estimated that over 80% of PE cases are associated with deep vein thrombosis (DVT). It is, therefore, easy to see why pulmonary embolism, for purposes of diagnosis and treatment, is often considered a complication or a consequence of DVT. A concern with this approach is that some cases of PE are due to embolization from other sites, such as pelvic or upper-extremity veins or the right heart, or even from in situ thrombosis.

Diagnostic efforts in radiology are aimed at: (1) reaching an acceptable level of diagnostic certainty of PE to warrant anticoagulant therapy, using the least invasive tests, and (2) excluding other reasons for the patient's symptoms. Historically, the probability of a patient having PE is typically arrived at using a Bayesian approach in which the pre-test likelihood of the condition (PE), based on clinical and laboratory evidence, is then modified by the results of the appropriate radiological procedure(s) in order to estimate a post-test probability of the condition. This approach has evolved over the last decade. Clinical decision trees, most notably the Wells criteria, have been developed and validated. There have also been major technological advances, primarily in computed tomography (CT) and magnetic resonance imaging (MRI). Many clinical studies have evaluated these modalities, and also the use of imaging in conjunction with clinical criteria and serum assay for D-dimer. High-sensitivity D-dimer testing, using an ELISA (enzyme-linked immunosorbent assay), has improved the specificity of the diagnosis of pulmonary embolism, D-dimer levels will be elevated with any significant thrombotic process, so this test is of limited value in pregnant, postoperative, and trauma patients. It is also of limited value in patients determined to be at high risk of PE by validated clinical criteria. In all other settings a negative D-dimer test effectively excludes pulmonary embolism or DVT.

Chest Radiograph

The posterior/anterior and lateral chest radiograph is an important initial study in the evaluation of suspected PE. The chest radiograph may eliminate the need for additional radiographic procedures by revealing an alternate reason for acute symptoms, such as pneumonia or a large effusion. A normal chest radiograph does not exclude PE, and there are no specific findings that are sufficient to confirm PE. A recent chest radiograph is required to allow accurate interpretation of an abnormal radionuclide ventilation/perfusion lung scan.

Computed Tomography

Multidetector computed tomography pulmonary angiography (CTPA) is indicated in the evaluation of patients suspected of having a PE. CTPA is now the primary imaging modality for evaluating patients suspected of having acute PE. CTPA has played an increasingly significant role in the diagnosis of PE since the first major clinical study in 1992. Technological advancements in CT, from helical to multidetector, have led to improved resolution of the pulmonary arteries, large and small. Numerous studies have examined the accuracy of CTPA as compared to ventilation/perfusion (V/Q) imaging and conventional angiography.

Multiple studies have shown that CTPA is highly sensitive and specific; discrepancies with conventional angiography are mainly at the subsegmental level where even angiographers tend to have poor inter-observer agreement. Intraobserver and interobserver variability for CTPA have been shown to be very good to the segmental level, better than with V/Q imaging.

The overall accuracy of CTPA appears to be very high, and is even higher when combined with clinical assessment and serum D-dimer testing. A positive CTPA result combined with high or intermediate suspicion on clinical assessment has a high positive predictive value. In patients with low clinical suspicion and a negative CTA, acute PE can safely be ruled out. In addition, the adjunctive use of CT venography with CTPA improves the

sensitivity of detecting DVT, with similar specificity, thereby increasing the overall accuracy of the diagnosis of thromboembolic disease, as compared to an isolated diagnosis of PE.

CTPA also has fewer "nondiagnostic" studies than V/Q scans. The false negative rate of CTPA is very low. Outcome studies have shown no adverse outcomes in patients with a negative CTPA who were not subsequently treated. Another study has shown CTPA to be cost-effective in conjunction with lower extremity duplex exams. The combination of multidetector CTPA and high-specificity D-dimer testing has very high positive and negative predictive values. In addition, CTPA may occasionally demonstrate pathology other than PE that may be responsible for the patient's symptoms.

CTPA can also identify signs of right ventricular dysfunction that may have prognostic significance or implications for treatment (e.g., need for the institution of thrombolytic therapy vs. conventional anticoagulation alone). Measurements of right ventricular enlargement and reflux of contrast to the inferior vena cava have been used among other indices to gauge right ventricular dysfunction and predict patient mortality. Recent technological advancements such as electrocardiogram (ECG)-gated CT and dual-source CT have allowed accurate evaluation of the pulmonary vasculature, thoracic aorta, and coronary arteries on a single CT study. This so-called "triple rule-out" CT protocol has been shown to be feasible, although it has yet to be proven useful or cost-effective through large-scale clinical trials. It is possible that the "triple rule-out" CT will become routine in the evaluation of certain patients with acute chest pain in the future.

In general, the data indicate that multidetector CTPA (MDCTPA) is more accurate than single-slice CT or other studies, such as V/Q scans. Conventional CT with contrast material (not performed as dedicated CTPA) is generally not indicated in the routine workup of acute chest pain thought to be secondary to acute PE.

Ventilation and Perfusion Imaging

Since its introduction in the mid-1960s, lung perfusion imaging has been indicated in the workup of patients with suspected PE. The role of lung perfusion imaging for evaluating suspected PE has considerably diminished with the widespread use of CTPA. Still, a normal pattern of regional perfusion in multiple projections accompanied by a normal ventilation scan is widely accepted as indicating that pulmonary emboli are not present and no further workup for PE is necessary. The choice between V/Q scans and CTPA remains somewhat controversial. Both modalities have overall good diagnostic accuracy, and, in the presence of a normal radiograph in a cooperative patient, a strong argument can be made that they are equivalent in diagnosing clinically significant pulmonary emboli.

An abnormal pattern of regional lung perfusion (Q) may suggest the diagnosis of PE, but it is not specific. It requires evaluation of the anatomic basis of the perfusion defect (i.e., segmental or not) as well as correlation with other modalities such as ventilation (V) imaging and a recent chest radiograph. These studies are performed to differentiate between reduced pulmonary arterial blood flow due to vascular obstruction and secondary reductions in regional blood flow associated with a variety of airways diseases.

A number of schemes based on various V/Q scan patterns have been developed to assign different probabilities for the presence (or absence) of PE. Generally, V/Q findings are categorized as: "high probability", "intermediate probability" (not meeting the criterion of either "high" or "low"), "low probability", "very low probability," and "normal". All the probability schemes incorporate the results of a recent chest radiograph. At least one study suggests that using single photon emission computed tomography (SPECT) imaging improves the sensitivity and specificity of V/Q scintigraphy.

Ventilation imaging may be performed either before or after technetium-99m (Tc-99m) macroaggregated albumin (MAA) perfusion imaging. Performing a low-dose MAA perfusion scan before the Xe-133 ventilation scan allows the ventilation scan to be obtained in the appropriate projection, rather than the usual posterior projection. Also, a normal perfusion scan can obviate the need to perform the ventilation scan, thus lowering radiation dose to the patient. Results with Tc-99m-labeled microaerosol agents (diethylenetriaminepentaacetic acid [DTPA], pertechnetate, etc.) are comparable to those of studies using inert gases such as xenon or krypton and have the advantage of providing multiple views for regional V/Q comparisons.

Lung scans sometimes may be indicated in pregnant women, in which case the administered dose of the radiopharmaceutical(s) should be reduced by a factor of two or more with correspondingly longer acquisition times to achieve adequate imaging statistics. Doing so may minimize radiation absorbed dose. If the MAA perfusion scan is performed first and is normal, the ventilation scan can be avoided.

A follow-up MAA perfusion scan may be recommended 6–8 weeks after the discovery of a "mismatched" V/Q pattern (presumption of PE). Failure of observed resolution or at least significant improvement in regional perfusion may signal the ultimate development of pulmonary hypertension secondary to chronic thromboembolic obstruction in the major pulmonary vessels. This complication has an expected incidence of less than 1%. Caution should be exercised in interpreting perfusion imaging in the days after acute PE, because reestablishment of regional perfusion (resolution of defects) occurs at varying and unpredictable rates. Conversely, local ventilation may be compromised for minutes to hours after an acute pulmonary embolism.

The modality of choice (CTPA versus V/Q scan) in pregnant patients remains a matter of debate. The maternal breast dose is clearly higher with CTPA, but whether or not the fetal dose is different remains unclear. Studies suggest that if the chest radiograph is normal, a perfusion scan alone may be satisfactory. Conversely, dose-lowering techniques may make the absorbed dose lower with CT.

MAA Perfusion Imaging without Ventilation Imaging

MAA perfusion imaging without ventilation may be indicated particularly when the condition of the patient suddenly deteriorates and acute PE is suspected as a significant contributory cause. A demonstration of regions of reduced perfusion, not explained by recent chest radiograph findings, warrants a consideration of PE and possibly the need for further workup such as pulmonary angiography. It may also be indicated in patients who are not candidates for MDCTPA, such as those who are too large for available CT gantries or who are unable to remain still and hold their breath for the few seconds necessary, or who have severe renal impairment.

Catheter-Directed Selective Pulmonary Angiography

Pulmonary angiography, including right heart catheterization and measurement of pulmonary artery and right heart pressures, is an acceptably safe, albeit invasive, procedure when performed by an experienced operator with adequate patient monitoring. The results may establish the specific diagnosis of PE when an acceptable level of certainty cannot be reached by noninvasive imaging. Given the accuracy of CTPA, however, unacceptably low levels of certainty are increasingly rare. Further, the experience of the radiologist who performs and interprets this invasive procedure is crucial. As indicated, studies suggest that the overall accuracy of catheter pulmonary angiography may be inferior to that of MDCTPA, due to technical factors such as patient movement and vessel overlap, as well as inter- and intra-observer variability in interpretation.

The amount of contrast material injected should be limited to that necessary to establish (or exclude) the presence of PE. The number of selective arterial injections may be reduced by focusing on suspicious pulmonary vascular territories indicated by the results of noninvasive V/Q lung scanning. Magnification techniques and imaging in special projection may overcome problems with overlapping vessels.

The general indications for pulmonary angiography in the past included a) cases with "low probability" or "intermediate probability" V/Q scan findings, particularly when there is a high clinical suspicion for PE, and anticoagulation is considered risky or relatively contraindicated; b) circumstances where a specific diagnosis of PE is considered necessary for the proper management of the patient; c) when pulmonary thromboendarterectomy or thrombolysis is considered (e.g., chronic pulmonary hypertension secondary to major vessel thromboembolic occlusion or symptomatic massive or submassive PE that may require catheter-directed therapy); and d) before placement of an inferior vena cava (IVC) filter. Because multidetector CTPA is currently the standard of care for PE detection, there are now fewer cases in which catheter pulmonary angiography is indicated or necessary, and these are now largely confined to situations in which catheter-directed thrombectomy or thrombolysis is thought to be clinically indicated.

Ultrasound

Transthoracic echo (TTE) and transesophageal echo (TEE) studies are generally not indicated in the diagnosis of acute PE in the setting of acute chest pain. However, these ultrasound (US) procedures are useful in evaluating right ventricular morphology and function that in turn have prognostic implications for morbidity, mortality, and development of future venous thromboembolism.

Because of the high association of DVT with PE, US evaluation of the venous drainage of the lower extremities is probably indicated. US studies include duplex Doppler with leg compression and continuous-wave Doppler. The presence of DVT does not indicate the presence (or absence) of PE, but may increase (or decrease) its likelihood. Also, positive DVT studies may identify patients at higher risk for subsequent PE. In most patients, however, the presence of DVT — whether or not associated with PE — has identical treatment, so no further diagnostic evaluation for PE is needed. A negative extremity US study does not exclude PE, although it significantly decreases its likelihood. For a more detailed discussion on DVT, refer to the National Guideline Clearinghouse (NGC) summary ACR Appropriateness Criteria® suspected lower-extremity deep vein thrombosis.

Magnetic Resonance Angiography, Magnetic Resonance Imaging, and Perfusion Imaging

Magnetic resonance angiography (MRA) and MR perfusion imaging can provide rapid, noninvasive evaluation of the central and segmental pulmonary arteries. MR perfusion imaging has high sensitivity for PE and is most useful when combined with magnetic resonance imaging (MRI) and MRA. Technologic innovations and increased experience may increase the role of MRA and MR perfusion imaging. Currently, MR is mainly used at institutions with particular interest in and expertise and experience with these techniques. It is also of at least theoretical value in pregnant patients, as well as patients in whom the use of iodinated contrast agents is contraindicated. While there are no studies to date suggesting that there is risk to a developing fetus, there is also no proof that the use of gadolinium-containing contrast agents is safe. They should, therefore, be used only when clearly indicated.

MRI without MRA is probably not indicated in the routine evaluation of patients with suspected PE. It may rarely be useful in patients who have

large central emboli, particularly if used in conjunction with MRI for other indications, such as cardiac morphologic evaluation.

Summary

- PE remains a common and important condition.
- A chest radiograph cannot exclude or confirm PE, but is important (as a complementary study) as it can guide further investigations and suggest alternative diagnoses.
- In general, any test that can confirm either DVT (i.e., lower-extremity venous duplex) or PE is sufficient. Only certain studies, however, have sufficient accuracy to exclude PE.
- Multislice CT pulmonary angiography is the current standard of care to confirm or exclude PE.
- V/Q scanning appears to also have high overall accuracy.
- In pregnancy, with radiation a particular concern, the choice between perfusion scanning and CTPA depends on local equipment and expertise as well as patient factors (normal chest radiograph, ability to breathhold).

Anticipated Exceptions

If multidetector CTPA is not available, then V/Q scans, pulmonary MRA and/or lower extremity ultrasound may need to be used for evaluation. The choice between CTPA and V/Q scanning in pregnant patients remains unresolved. With careful, modern techniques, both are acceptable. The radiation dose to the fetus, in general, is probably lower with V/Q scanning, although dose modulation techniques with CT may make the two modalities nearly equivalent in absorbed dose. If a chest radiograph is abnormal, CTPA has a higher likelihood of being definitive.

Nephrogenic systemic fibrosis (NSF) is a disorder with a scleroderma-like presentation and a spectrum of manifestations that can range from limited clinical sequelae to fatality. It appears to be related to both underlying severe renal dysfunction and the administration of gadolinium-based contrast agents. It has occurred primarily in patients on dialysis, rarely in patients with very limited glomerular filtration rate (GFR) (i.e., <30 mL/min/1.73 m^2), and almost never in other patients. There is growing literature regarding NSF. Although some controversy and lack of clarity remain, there is a consensus that it is advisable to avoid all gadolinium-based contrast agents in dialysis-dependent patients unless the possible benefits clearly outweigh the risk, and to limit the type and amount in patients with estimated GFR rates <30 mL/min/1.73 m^2. For more information, please see the ACR Manual on Contrast Media (see the "Availability of Companion Documents" field).

Abbreviations

- CTA, computed tomography angiography
- MRA, magnetic resonance angiography
- PE, pulmonary embolism
- RV, right ventricular
- US, ultrasound
- V/Q, ventilation/perfusion
- Tc, technetium

Relative Radiation Level Designations

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	0 mSv	0 mSv
	<0.1 mSv	<0.03 mSv
	0.1-1 mSv	0.03-0.3 mSv
	1-10 mSv	0.3-3 mSv
	10-30 mSv	3-10 mSv
	30-100 mSv	10-30 mSv
*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (e.g., region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as NS (not specified).		

Clinical Algorithm(s)

Algorithms were not developed from criteria guidelines.

Scope

Disease/Condition(s)

- Acute chest pain
- Suspected pulmonary embolism

Guideline Category

Diagnosis

Evaluation

Clinical Specialty

Cardiology

Critical Care

Emergency Medicine

Family Practice

Internal Medicine

Nuclear Medicine

Obstetrics and Gynecology

Pulmonary Medicine

Radiology

Intended Users

Health Plans

Hospitals

Managed Care Organizations

Physicians

Utilization Management

Guideline Objective(s)

To evaluate the appropriateness of initial radiologic examinations for patients with acute chest pain caused by suspected pulmonary embolism

Target Population

Patients with acute chest pain caused by suspected pulmonary embolism

Interventions and Practices Considered

1. X-ray, chest
2. Computed tomography angiography (CTA), chest
    - Noncoronary, with contrast
    - With contrast, with CT venography, lower extremities
3. Ultrasound (US)
    - Lower extremity with Doppler
    - Echocardiography, transesophageal (TEE)
    - Echocardiography, transthoracic (TTE) resting
4. Tc-99m ventilation/perfusion (V/Q) scan, lung
5. Pulmonary angiography with right heart catheterization
6. Magnetic resonance angiography (MRA)
    - Pulmonary arteries without and with contrast
    - Pulmonary arteries without contrast

Major Outcomes Considered

- Utility of radiologic examinations in differential diagnosis
- Predictive value of diagnostic tests

Methodology

Methods Used to Collect/Select the Evidence

Searches of Electronic Databases

Description of Methods Used to Collect/Select the Evidence

Literature Search Procedure

The Medline literature search is based on keywords provided by the topic author. The two general classes of keywords are those related to the condition (e.g., ankle pain, fever) and those that describe the diagnostic or therapeutic intervention of interest (e.g., mammography, MRI).

The search terms and parameters are manipulated to produce the most relevant, current evidence to address the American College of Radiology Appropriateness Criteria (ACR AC) topic being reviewed or developed. Combining the clinical conditions and diagnostic modalities or therapeutic procedures narrows the search to be relevant to the topic. Exploding the term "diagnostic imaging" captures relevant results for diagnostic topics.

The following criteria/limits are used in the searches.

1. Articles that have abstracts available and are concerned with humans.
2. Restrict the search to the year prior to the last topic update or in some cases the author of the topic may specify which year range to use in the search. For new topics, the year range is restricted to the last 5 years unless the topic author provides other instructions.
3. May restrict the search to Adults only or Pediatrics only.
4. Articles consisting of only summaries or case reports are often excluded from final results.

The search strategy may be revised to improve the output as needed.

Number of Source Documents

The total number of source documents identified as the result of the literature search is not known.

Methods Used to Assess the Quality and Strength of the Evidence

Weighting According to a Rating Scheme (Scheme Given)

Rating Scheme for the Strength of the Evidence

Strength of Evidence Key

Category 1 - The conclusions of the study are valid and strongly supported by study design, analysis and results.

Category 2 - The conclusions of the study are likely valid, but study design does not permit certainty.

Category 3 - The conclusions of the study may be valid but the evidence supporting the conclusions is inconclusive or equivocal.

Category 4 - The conclusions of the study may not be valid because the evidence may not be reliable given the study design or analysis

Methods Used to Analyze the Evidence

Systematic Review with Evidence Tables

Description of the Methods Used to Analyze the Evidence

The topic author drafts or revises the narrative text summarizing the evidence found in the literature. American College of Radiology (ACR) staff draft an evidence table based on the analysis of the selected literature. These tables rate the strength of the evidence for all articles included in the narrative text.

The expert panel reviews the narrative text, evidence table, and the supporting literature for each of the topic-variant combinations and assigns an appropriateness rating for each procedure listed in the table. Each individual panel member forms his/her own opinion based on his/her interpretation of the available evidence.

More information about the evidence table development process can be found in the American College of Radiology (ACR) Appropriateness Criteria® Evidence Table Development document (see the "Availability of Companion Documents" field).

Methods Used to Formulate the Recommendations

Expert Consensus (Delphi)

Description of Methods Used to Formulate the Recommendations

Modified Delphi Technique

The appropriateness ratings for each of the procedures included in the Appropriateness Criteria topics are determined using a modified Delphi methodology. A series of surveys are conducted to elicit each panelist's expert interpretation of the evidence, based on the available data, regarding the appropriateness of an imaging or therapeutic procedure for a specific clinical scenario. American College of Radiology (ACR) staff distributes surveys to the panelists along with the evidence table and narrative. Each panelist interprets the available evidence and rates each procedure. The surveys are completed by panelists without consulting other panelists. The ratings are a scale between 1 and 9, which is further divided into three categories: 1, 2, or 3 is defined as "usually not appropriate"; 4, 5, or 6 is defined as "may be appropriate"; and 7, 8, or 9 is defined as "usually appropriate." Each panel member assigns one rating for each procedure per survey round. The surveys are collected and the results are tabulated, de-identified and redistributed after each round. A maximum of three rounds are conducted. The modified Delphi technique enables each panelist to express individual interpretations of the evidence and his or her expert opinion without excessive bias from fellow panelists in a simple, standardized and economical process.

Consensus among the panel members must be achieved to determine the final rating for each procedure. Consensus is defined as eighty percent (80%) agreement within a rating category. The final rating is determined by the median of all the ratings once consensus has been reached. Up to three rating rounds are conducted to achieve consensus.

If consensus is not reached, the panel is convened by conference call. The strengths and weaknesses of each imaging procedure that has not reached consensus are discussed and a final rating is proposed. If the panelists on the call agree, the rating is accepted as the panel's consensus. The document is circulated to all the panelists to make the final determination. If consensus cannot be reached on the call or when the document is circulated, "No consensus" appears in the rating column and the reasons for this decision are added to the comment sections.

Rating Scheme for the Strength of the Recommendations

Not applicable

Cost Analysis

The guideline developers reviewed published cost analyses.

Method of Guideline Validation

Internal Peer Review

Description of Method of Guideline Validation

Criteria developed by the Expert Panels are reviewed by the American College of Radiology (ACR) Committee on Appropriateness Criteria.

Evidence Supporting the Recommendations

Type of Evidence Supporting the Recommendations

The recommendations are based on analysis of the current literature and expert panel consensus.

Benefits/Harms of Implementing the Guideline Recommendations

Potential Benefits

Selection of appropriate radiologic imaging procedures for evaluation of patients with acute chest pain caused by suspected pulmonary embolism

Potential Harms

Caution should be exercised in interpreting perfusion imaging in the days after acute pulmonary embolism (PE), because reestablishment of regional perfusion (resolution of defects) occurs at varying and unpredictable rates. Conversely, local ventilation may be compromised for minutes to hours after an acute pulmonary embolism.

Gadolinium-based Contrast Agents

Nephrogenic systemic fibrosis (NSF) is a disorder with a scleroderma-like presentation and a spectrum of manifestations that can range from limited clinical sequelae to fatality. It appears to be related to both underlying severe renal dysfunction and the administration of gadolinium-based contrast agents. It has occurred primarily in patients on dialysis, rarely in patients with very limited glomerular filtration rate (GFR) (i.e., <30 mL/min/1.73 m^2), and almost never in other patients. Although some controversy and lack of clarity remain, there is a consensus that it is advisable

to avoid all gadolinium-based contrast agents in dialysis-dependent patients unless the possible benefits clearly outweigh the risk, and to limit the type and amount in patients with estimated GFR rates <30 mL/min/1.73 m^2. For more information, please see the ACR Manual on Contrast Media (see the "Availability of Companion Documents" field).

Relative Radiation Level (RRL)

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults. Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document (see "Availability of Companion Documents" field).

Qualifying Statements

Qualifying Statements

Qualifying Statements

An American College of Radiology (ACR) Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists, and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the U.S. Food and Drug Administration (FDA) have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.

Implementation of the Guideline

Description of Implementation Strategy

An implementation strategy was not provided.

Institute of Medicine (IOM) National Healthcare Quality Report Categories

IOM Care Need

Getting Better

IOM Domain

Effectiveness

Identifying Information and Availability

Bibliographic Source(s)

Bettmann MA, Baginski SG, White RD, Woodard PK, Abbara S, Atalay MK, Dorbala S, Haramati LB, Hendel RC, Martin ET III, Ryan T, Steiner RM, Expert Panel on Cardiac Imaging. ACR Appropriateness CriteriaÂ® acute chest pain - suspected pulmonary embolism. [online publication]. Reston (VA): American College of Radiology (ACR); 2011. 7 p. [68 references]

Adaptation

Not applicable: The guideline was not adapted from another source.

Date Released

1995 (revised 2011)

Guideline Developer(s)

American College of Radiology - Medical Specialty Society

Source(s) of Funding

The American College of Radiology (ACR) provided the funding and the resources for these ACR Appropriateness Criteria®.

Guideline Committee

Committee on Appropriateness Criteria, Expert Panel on Cardiac Imaging

Composition of Group That Authored the Guideline

Panel Members: Michael A. Bettmann, MD; Scott G. Baginski, MD; Richard D. White, MD; Pamela K. Woodard, MD; Suhny Abbara, MD; Michael K. Atalay, MD, PhD; Sharmila Dorbala, MD; Linda B. Haramati, MD, MS; Robert C. Hendel, MD; Edward T. Martin, III, MD; Thomas Ryan, MD; Robert M. Steiner, MD

Financial Disclosures/Conflicts of Interest

Not stated

Guideline Status

Note: This guideline has been updated. The National Guideline Clearinghouse (NGC) is working to update this summary.

Guideline Availability

Electronic copies of the updated guideline: Available from the American College of Radiology (ACR) Web site .

Print copies: Available from the American College of Radiology, 1891 Preston White Drive, Reston, VA 20191. Telephone: (703) 648-8900.

Availability of Companion Documents

The following are available:

- ACR Appropriateness Criteria®. Overview. Reston (VA): American College of Radiology; 2 p. Electronic copies: Available in Portable Document Format (PDF) from the American College of Radiology (ACR) Web site.
- ACR Appropriateness Criteria®. Literature search process. Reston (VA): American College of Radiology; 1 p. Electronic copies: Available in Portable Document Format (PDF) from the ACR Web site.
- ACR Appropriateness Criteria®. Evidence table development – diagnostic studies. Reston (VA): American College of Radiology; 2013 Nov. 3 p. Electronic copies: Available in PDF from the ACR Web site.
- ACR Appropriateness Criteria®. Radiation dose assessment introduction. Reston (VA): American College of Radiology; 2 p. Electronic copies: Available in Portable Document Format (PDF) from the ACR Web site.
- ACR Appropriateness Criteria® Manual on contrast media. Reston (VA): American College of Radiology; 90 p. Electronic copies: Available in PDF from the ACR Web site.
- ACR Appropriateness Criteria® acute chest pain — suspected pulmonary embolism. Evidence table. Reston (VA): American College of Radiology; 2011. 22 p. Electronic copies: Available from the ACR Web site.

Patient Resources

None available

NGC Status

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